PROCEEDINGS

53. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Faculty of
Mechanical Engineering

PROSPECTS IN MECHANICAL ENGINEERING

8 - 12 September 2008

www.tu-ilmenau.de

TECHNISCHE UNIVERSITÄT
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Published by
Impressum

Publisher Herausgeber	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c. Peter Scharff
Editor Redaktion	Referat Marketing und Studentische Angelegenheiten Andrea Schneider Fakultät für Maschinenbau Univ.-Prof. Dr.-Ing. habil. Peter Kurz, Univ.-Prof. Dr.-Ing. habil. Rainer Grünwald, Univ.-Prof. Dr.-Ing. habil. Prof. h. c. Dr. h. c. mult. Gerd Jäger, Dr.-Ing Beate Schlütter, Dipl.-Ing. Silke Stauche
Editorial Deadline Redaktionsschluss	17. August 2008
Publishing House Verlag	Verlag ISLE, Betriebsstätte des ISLE e.V. Werner-von-Siemens-Str. 16, 98693 Ilmenau

CD-ROM-Version:

Implementation Realisierung	Technische Universität Ilmenau Christian Weigel, Helge Drumm
Production Herstellung	CDA Datenträger Albrechts GmbH, 98529 Suhl/Albrechts

ISBN: 978-3-938843-40-6 (CD-ROM-Version)

Online-Version:

Implementation Realisierung	Universitätsbibliothek Ilmenau ilmedia Postfach 10 05 65 98684 Ilmenau

Home / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=17534

53rd Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
08 – 12 September 2008

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Fuzzy Control of Aerial Vehicle Landing

This article deals with the possibility of using optical system for correction movement of an aircraft during landing in area given by landmarks under conditions of adverse visibility. The algorithm founded on fuzzy logic is used in method of the image recognition. The problem of unmanned aircraft landing on signal objects is considered in the article. Suppose that there are two signal objects on direction of moving an aircraft. The problem is clearly to select these objects.

INTRODUCTION

To date an automatic pointing of aerial vehicles is one of important tasks in designing of control systems. One of the most critical problems is an automatic landing. Due to quick time of the landing process the global positioning systems or internal navigation systems are supplemented with the vision-based navigation systems [1]. We propose the fuzzy control system for landing based on processing of pictures area. The goal of control is direct hit between light beacons according to ideal glide path. For this purpose four light beacons as a virtual gate for aerial vehicle are used. Figure 1 illustrates proposed scheme.

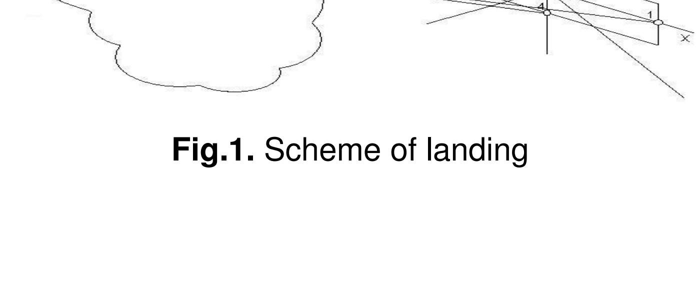

Fig.1. Scheme of landing

MODEL OF AERIAL VEHICLE

We consider here the lateral channel and yaw control only. The model of lateral movement of the vehicle can be presented as following system [2]:

$$
\begin{aligned}
&\dot{x}_1 = -n_{11}x_1 - n_{14}x_2 - n_{12}x_3 - n_{13}x_5, \\
&\dot{x}_2 = x_3, \\
&\dot{x}_3 = -n_{21}x_1 - n_{22}x_3 - n_{23}x_5 - n_e\delta_e, \\
&\dot{x}_4 = x_5, \\
&\dot{x}_5 = -n_{31}x_1 - n_{32}x_3 - n_{33}x_5 - n_c\delta_c + f_y,
\end{aligned}
$$

where the state variables mean $x_1 = \beta$, $x_2 = \gamma$ $x_3 = \omega_x = \dot{\gamma}$, $x_4 = \psi$, $x_5 = \omega_y = \dot{\psi}$, namely, β is a grazing angle, γ is an angle of bank, ψ is a course angle. Variables δ_e and δ_c are functions of aileron and course control respectively. Variable f_y is external disturbance and coefficients n_{ij} are calculated from physical model.

STRUCTURE OF FUZZY CONTROL

We propose the following set of mapping for generate the control:

$$R : \psi, \gamma, \delta \to \Delta \;\; , Q : \Delta \to \{\delta_e, \delta_c\}.$$

The mapping R is an analytical function that calculates relative distance Δ between coordinates of the points $\{1,3\}$ from Fig.1. Using fuzzy Mamdani model we design the second mapping Q that calculates the desire control values. The appropriate rule base has rules like

$IF\ \Delta\, is\ NB\ THEN\ \delta_e\ is\ PB\, and\ \delta_c\ is\ ZE$,

where $NB, PB, ZE, ...$ are linguistic variables.

There is video frame which is delivered on fuzzy-controller. Input – output variables are created. Input variables are color, current_i, current_j. Output variables are squre_1, squre_2, squre_3, squre_4, where squre_i, i = 1..4 are arrays (Fig.2).

In consequence of which our frame (area) is partitioned into four squares (Fig. 3).

Variable name	Values of variable
color	black, gray, middle, misty, white
current_i	small, big
current_j	small, big
squre_1	black, gray, middle, misty, white
squre_2	black, gray, middle, misty, white
squre_3	black, gray, middle, misty, white
squre_4	black, gray, middle, misty, white

Fig. 2. FIS variables

i / j	small	big
small	1	2
big	3	4

Fig. 3. Frame partition into logical squares

The rules of the fuzzy logic are created. All points are distributed on square and partitioned by brightness according to these rules. With the help of FIS Editor rules [4] the set of the rules for our fuzzy model is created (Fig. 4).

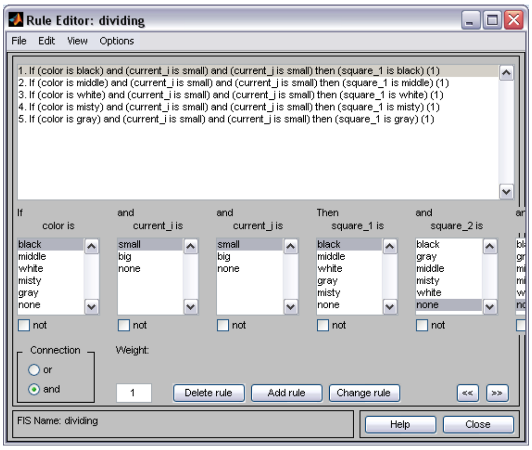

Fig. 4. Graphic interface of FIS Editor rules

Similarly the other rules for the rest three squares are made. We receive from one to four arrays with points and their brightnesses. There are following variants of two points location on the area consisting of four squares:

(1,2) (1,3) (1,4) (2,3) (2,4) (3,4) (1,1) (2,2) (3,3) (4,4)

For one point on the area – (1) (2) (3) (4).

In each square the darkest color is chosen. The square(s) which has (have) the darkest color is white is (are) deleted. If there are two squares with the darkest color then they are left for further recognition.

If there are two points in two different squares then they are selected by similar fuzzy algorithms. If there is only one nonempty output variable then revision is continued by similar algorithm. It can give two variants:

we have one point – command is given on camera shift;

we have two points – next revision by such algorithm is made.

If all outputs are empty then the algorithm of intensified searching is included.

The criterion of stop is no more than 10 points in each of output variables.

The correction of fuzzy algorithm: in the following partitions the darker colors than those which have got points in the first partition are not used (complexity of the calculations is reduced).

CONCLUSION

In this article the recognition algorithm using the fuzzy logic was considered. Above described the fuzzy model allows to recognize the points on the image taking into account their brightnesses and also to facilitate their further searching on contrast. This fuzzy model is an alternative to search algorithm. The purpose of this scientific research is the optimization of flight path and landing control of an aircraft with specified coordinates.

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